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ABSTRACT

This experiment asked whether infants at 5 months perceived an invariant over four types of rigid motion (perspective transformations), and thereby differentiated rigid motion from deformation. Four perspective transformations of a sponge rubber object (rotation around the vertical axis, rotation around the horizontal axis, rotation in the frontal plane, and looming back and forth) were contrasted with a rubbery "squeezing" motion of the same object. Twenty-four infants were habituated to three of the perspective transformations and tested on a pre- and post-test with a fourth perspective transformation and with the deforming motion. The dependent variable was looking time. Backward habituation curves showed a rise in looking time when the post-test was introduced after habituation, but a greater rise for the deformation than for the rigid transformation. Analysis of variance confirmed that the type of motion (rigid or deforming) was significant in determining degree of habituation. The inference was made that the infants perceived the invariant property of rigidity in all four perspective transformations and thus differentiated them from deformation. (Author/MS)

Perception of Invariance Over Perspective Transformations in Five Month Old Infants

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A question of central importance to a theory of perception is, how do we come to perceive the world as having a stable, ordered layout, furnished with objects having permanent properties, despite the fact that we ourselves and the objects of the world are often moving. Experiments on the perception of the world's permanent properties, despite an observer's changing perspective, have become more numerous in recent years. Witness the increasing literatures on size, distance, and shape constancy, object permanence, and perception of an objective spatial layout. The question of how stability is perceived despite change has seldom been put to the very young infant; instead most studies on infant perception utilize as stimuli static representations. It is readily apparent that this experimental approach does not address the original question; if we are to discover when and how the young infant perceives identity in an array which changes over time, it is requisite that we observe him under conditions where he has the opportunity to view a varying environment.

Adults and children, in real world instances, perceive an object as having a stable, rigid shape despite the fact that it may be undergoing a family of continuous perspective transformations. When an object undergoes a perspective transformation (e.g., rotation around its horizontal axis), all texture elements on the surface of that object are being dis-

placed relative to the same axis. Further, it can be claimed that the relationship among those elements remains invariant throughout the transformations. Thus, this invariant relationship provides information that we can use to perceive a rigid object.

Non-rigid, or deforming, motions are also typical ways that objects change. As contrasted with a perspective transformation where texture elements are moving relative to the same axis, in most deforming motions texture elements are being displaced around several axes simultaneously. The relationship between the surface elements does not remain invariant over the deforming motion. But the fact that motion exists around more than one axis at one point in time is itself informative and can have a role in specifying a non-rigid object. A different kind of invariant exists if the deforming transformation is reversible; we are likely to perceive an elastic or spongey object.

We believe that it is reasonable to assume that the pick-up of invariants, such as these, serves as a basis for our perception of a stable, ordered world. The invariant relationships existing in a changing flux of stimulation can be viewed as specifying the permanent properties of the environment (such as an object's shape). It is the pick-up of these invariants which also allows the perceiver to differentiate between objects on the basis of some characteristic such as rigidity vs. elasticity. The current experiment is concerned with the latter issue: Are young infants capable of differentiating between a rigid and a deforming motion? In other words, how early are they sensitive to the information which specifies a rigid vs. non-rigid object?

Four perspective transformations of a sponge rubber object served as the rigid motions in this experiment. They included rotation around

the vertical axis, rotation around the horizontal axis, rotation in the frontal plane, and looming back and forth. Pictured in the first slide is the object rotating on its horizontal axis.

Slide 1

The deforming motion consisted of a squeezing of the object and is pictured on the second slide.

Slide 2

We chose the habituation paradigm; the general procedure is outlined on the next slide.

Slide 3

Twenty-four subjects (mean age five months) were presented with three rigid motions in a consecutive fashion. The next motion in the sequence was presented when an infant looked away from the current display for two seconds. Presentations were continued until a criterion of habituation was reached for all three motions. The criterion was defined for each infant as one-half of its fixation on the first or second habituation exposure, whichever was longer.

When the criterion of habituation had been met, a post-test was presented which included a fourth rigid motion, the one that was not presented for habituation, and a deformation. One group of twelve subjects saw the new rigid motion first, while the other group saw the deformation first. The post-test was repeated. Notice that a pre-test was given before the habituation sequence, to determine if one motion was intrinsically more interesting than the other.

The dependent measure was total looking time, as recorded by an observer looking through a peephole. The observer was blind with respect to the current motion as well as to the experimental condition.

Backward habituation curves were plotted for both groups, following Cohen's procedure. The next slide depicts the curve for those subjects who saw deformation first in the pre-and post-tests.

Slide 4

Log transformations were performed on looking times to normalize the distribution, which was positively skewed. A three-motion sequence is represented by a single point on the habituation portion of the graph. Notice that there is greater dishabituation to deformation than there is to the fourth rigid motion and that this difference is maintained when the post-test is repeated. The results of the group which saw the fourth rigid motion first are pictured on the next slide; the pattern of results are

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Slide 5
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quite similar in that there was more fixation on the deformation.

An analysis of variance was performed which utilized as a within-subject factor the differential increase in looking time from the last look of habituation to deformation vs. the fourth rigid motion. To get this difference score, we subtracted duration of the last look of habituation from duration of the looking time to deformation and to the new rigid motion in the post-test. Results indicated that there was a significantly larger increase in fixation to the deformation as compared to the fourth rigid motion ($F(1,22) = 8.94$, $p < .007$). The other two factors in the analysis of variance, sex and order of presentation of motion in the pre-and post-tests, were both non-significant.

Was deformation intrinsically more interesting regardless of habituation? We examined the pretest scores and found that there was no difference in looking preference to the two kinds of motion before habituation. Furthermore, the differences in dishabituation to the two kinds of motion in the post-test cannot be attributed to the overpowering effects of just one or two rigid motions; in a comparison of fixation immediately preceding and following habituation, an analysis of variance with the four perspective transformations separated as factors yielded no significant differences.

These data seem to us to show that after being habituated to a series of rigid motions, infants will show greater dishabituation to a deformation than to a new rigid motion. We were also interested in determining whether either of these increases in attention was greater than an increase that would be expected if no change of motion was introduced. To this end, we ran a control group of ten babies who continued to see the same rigid motions in the post-test as they had observed in habituation. Statistical analyses indicated that dishabituation to the deformation was significantly greater than the change of looking time in the control group ($t = 1.82$, $p < .05$, one-tailed), whereas dishabituation to the new rigid motion was not.

The results of the present experiment suggest that five-month-olds perceive a stable, rigid object over perspective transformations. During habituation they were able to pick up invariant information that specified a rigid object across three perspective transformations. This invariant was maintained in the array when the object underwent a new perspective transformation; thus, habituation generalized to the fourth rigid motion. On the other hand, dishabituation did occur when infants viewed the deformation, indicating that they were able to detect a shift in the information which specifies a rigid vs. elastic object. It is unnecessary (and in

fact unreasonable) to explain these results in terms of abstraction of a static feature and assessment of its presence in future stimulus displays; the invariance was maintained in the array over time, continuously available for detection.

We conclude that five month old infants are capable of perceiving stability over change, and we maintain that this is made possible in part by the detection of invariant relationships in the varying array. Objects and events can be uniquely specified in stimulation by these invariants, which serve as a basis for their differentiation. Our evidence that a young infant can perceive a stable, rigid object and can differentiate it from a deforming one suggests the primacy of these principles for a theory of perception.